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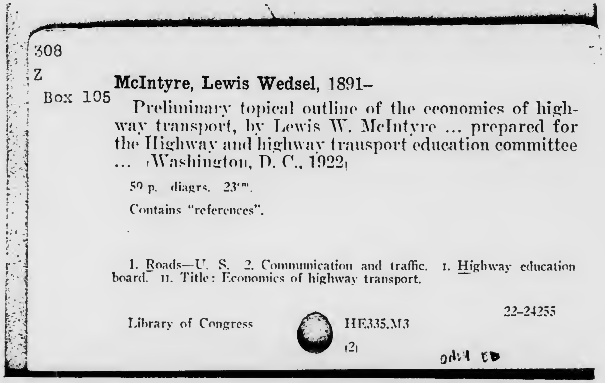

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PRELIMINARY
TOPICAL OUTLINE *of the* ECONOMICS *of* HIGHWAY TRANSPORT

by

LEWIS W. McINTYRE
Assistant Professor of Civil Engineering, University of Pittsburgh;
Associate Member, American Society of Civil Engineers;
Member, Society for the Promotion of Engineering Education

Prepared for the

HIGHWAY AND HIGHWAY TRANSPORT
EDUCATION COMMITTEE

THE HIGHWAY AND HIGHWAY TRANSPORT EDUCATION COMMITTEE

WILLARD BUILDING, WASHINGTON, D. C.

Appointed May 28, 1920, by Dr. P. P. Claxton,
Former Commissioner of Education.

John J. Tigert, Chairman, U. S. Commissioner of Education.

Thos. H. MacDonald, Chief, Bureau of Public Roads, Department of Agriculture.

F. C. Boggs, Colonel, Corps of Engineers, U. S. A., representing the War Department.

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W. C. John, Acting Director.

Pyke Johnson, Secretary.

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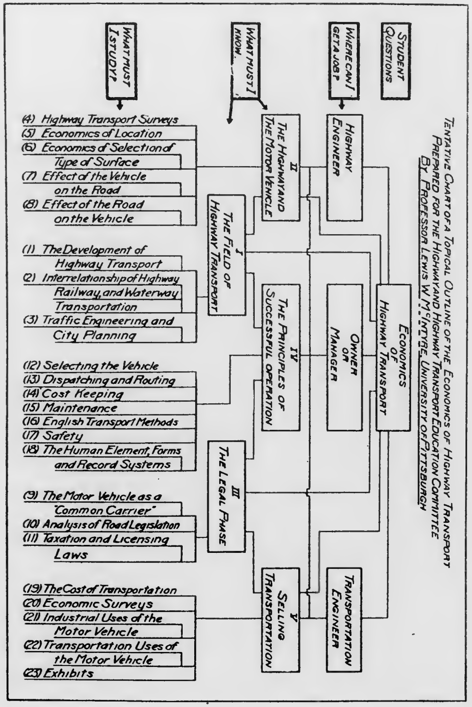

Tentative Chart of a Topical Outline of the Economics of Highway Transport
Prepared for the Highway and Highway Transport Education Committee
By Professor Lewis W. McIntyre, University of Pittsburgh

Student Questions
Where can I get a job?
What must I know?
What must I study?
Economics of Highway Transport
Highway Engineer
Owner or Manager
Transportation Engineer
II The Highway and the Motor Vehicle
I The Field of Highway Transport
IV The Principles of Successful Operation
III The Legal Phase
V Selling Transportation
(4) Highway Transport Surveys
(5) Economics of Location
(6) Economics of Selection of Type of Surface
(7) Effect of the Vehicle on the Road
(8) Effect of the Road on the Vehicle
(1) The Development of Highway Transport
(2) Interrelationship of Highway Railway and Waterway Transportation
(3) Traffic Engineering and City Planning
(12) Selecting the Vehicle
(13) Dispatching and Routing
(14) Cost Keeping
(15) Maintenance
(16) English Transport Methods
(17) Safety
(18) The Human Element, Forms and Record Systems
(9) The Motor Vehicle as a "Common Carrier"
(10) Analysis of Road Legislation
(11) Taxation and Licensing Laws
(19) The Cost of Transportation
(20) Economic Surveys
(21) Industrial Uses of the Motor Vehicle
(22) Transportation Uses of the Motor Vehicle
(23) Exhibits

PREFACE

This bulletin forms a part of a topical outline in the Economics of Highway Transport and is issued by the Highway and Highway Transport Education Committee as a part of their work in furthering Highway Transport Education. It is issued for a dual purpose. By its distribution to selected college or engineering students it may assist them in forming a more definite idea of the field of highway transport and aid them in getting a vision of the opportunities for future employment in this field. It is hoped also that in those colleges where courses in highway transport are being given, or are being contemplated, it may assist teachers of this subject in the formulation of adequate courses with a minimum of duplicated effort on their part.

As state and county officers have felt increasing pressure demanding more adequate facilities for highway transport development, they have felt the need for fundamental economic data justifying the investment and expenditure of the funds entrusted to them. It is felt that this outline may stimulate interest in the economic phases of the subject and possibly aid in the equipment of experts at our various Universities to whom the same officers and tax payers alike may turn for the fundamental data on which these developments may be built.

The outline makes no pretense of being either complete or adequate. It has been limited in various ways. The newness of the subject and the consequent lack of authoritative research make definite conclusions and principles impossible. Its preparation was not undertaken until December first and then only in addition to other work. The reason for this haste is the continued urgent requests from the Schools of Engineering and Schools of Economics of the country to the Committee that something of a preliminary nature be made available for their use during the second semester of the present school year. An effort has, therefore, been made to avoid the expression of an opinion, but to present both sides of debatable questions.

Some of the topics are capable of considerable expansion; their use will be determined by the local situation. Others may be used almost as outlined. It is confidently expected that use of the outline will develop innumerable suggestions for its revision. Such suggestions or criticisms will be greatly appreciated.

The references by no means constitute a complete bibliography of the subject; neither is it at all essential that all of them be read. Quite often the meat of the reference is only a very small part of the published article and it is hoped that the more important references may shortly be abstracted for more convenient use. In many cases similar references can be found in periodicals more easily available to the individual. Here again lack of time has been the handicap rendering the best selection of these references difficult.

For the very great help rendered in the preparation of this outline by the suggestion of subject matter, the furnishing of information, the criticism of content, and the inspiration of personal contact, acknowledgment is made to the following:

Mr. A. T. Goldbeck, Engineer of Tests, Bureau of Public Roads.
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Dean A. N. Johnson, University of Maryland.

The list of contemplated topics, a portion of which are published in this bulletin and the remainder of which it is expected will be published at an early date, follows:

University of Pittsburgh, January 14, 1922.

TENTATIVE CONTENT OF OUTLINE

I. THE FIELD OF HIGHWAY TRANSPORT.

(1) The Development of Highway Transport.
Steps in the development; relation of transportation to civilization; problems awaiting solution; magnitude of the problems; the highway program; the field for trained men; salaries available; probable future development.

(2) Interrelationship of Highway, Railway and Waterway Transportation.
Correlation of all forms of service (Cincinnati plan, unit containers, store door delivery, etc.); the electric railway and highway transport; the steam railway and highway transport; the waterway and highway transport.

(3) Traffic Engineering and City Planning.
Relation of transportation problems to city planning; historical development of city transportation; street traffic problems; street railway problems; traffic regulation.

II. THE HIGHWAY AND THE MOTOR VEHICLE.

(4) Highway Transportation Surveys.
The traffic census, its purpose, use, and limitations; economic survey of transportation; needs of local industries; use of vehicle registration data; intangibles; capacity; peak loads, etc.

(5) Economics of Location.
General considerations; minor details of alignment (distance, curvature, rise and fall and their effect on the cost of transportation); ruling gradient and curvature; typical calculations of the effect of these items on operating expenses; justifiable expenditure for their reduction; virtual profile.

(6) Economics of the Selection of Type of Surface.
Adaption of motor vehicle and highway to one another; limiting factors; economical traffic unit; typical calculation of economical traffic unit; other factors effecting type of construction; economical life.

(7) Effect of the Vehicle on the Road.
Type of vehicle (horsedrawn, high-speed rubber-tired, motor truck); stresses induced; types of failure; effect of weight; effect of speed; impact; experimental investigations; types of roads, rigid and non-rigid; traffic intensity; unsprung weight; pneumatic and cushion tires.

(8) The Effect of the Road On the Vehicle.
Stresses in the motor vehicle; stresses due to load; twisting strains caused by road irregularities, shocks caused by rough roads; driving shocks and loads; braking shocks and loads.

III. THE LEGAL PHASE.

(9) The Motor Vehicle as a Common Carrier.
The trend of existing legislation; operation on regular routes; hauling for selected patrons; passenger service; freight service; effect of regulation; result of non-regulation; arguments pro and con; constitution of the regulating body; franchises and rate making.

(10) Analysis of Road Legislation.
Development of the theory of road laws; analysis of existing laws; effect on transportation; possible changes.

(11) Taxation and Licensing Laws.
Methods of taxation, gasoline tax, tonnage tax, tax according to use, etc.; weaknesses of present systems; outlook for the future.

IV. THE PRINCIPLES OF SUCCESSFUL OPERATION.

(12) Selecting the Vehicle.
General requirements; types available; vocational surveys; factors effecting selection; body design; trailers, their advantages and when to use them; demountable bodies; special bodies; tires.

(13) Dispatching and Routing.
Fundamental principles; scheduling; co-ordination of loads and vehicles; zone system; analyzing routes by time studies; minimizing delays at ferries, terminals, etc.; selecting of routes; loading and unloading devices.

(14) Cost Keeping

Importance; desirability of uniform system; results desired (economic unit, ton mile costs, etc.); data necessary; National Standard Cost System; Commercial Vehicle System; other systems.

(15) Maintenance.

Serious effect of improper maintenance; lubrication, inspection; effect of over loading; effect of over speeding, typical systems of maintenance; garage problems.

(16) English Transport Methods.

European transport problems and their solution; types of commercial vehicles; legislation in force in 1922; highway transport methods.

(17) Safety.

Grade crossings; guard rails; footpaths, etc.

(18) The Human Element; Forms and Record Systems, Etc.

Importance of esprit de corps and how to maintain it; typical bonus systems; mechanical checking devices; bills of lading, etc.

V. SELLING TRANSPORTATION.

(19) The Cost of Transportation.

Factors entering into complete cost of transportation; crating, terminal charges, etc.; effect of road conditions on cost of highway transport.

(20) Economic Surveys.

Purpose; surveys of business operations; public haulage surveys; community transportation surveys; motor truck terminals; snow removal.

(21) Industrial Uses of the Motor Vehicle.

Farming; lumbering; mining; factory; construction; municipal haulage.

(22) Transportation Uses of the Motor Vehicle.

As feeder to railways and waterways; flanged wheel equipment; inter-city trucking companies; rural motor express; motor busses; local uses; long and short rural haulage.

(23) Exhibits.

Highway, rubber, and automotive exhibits.

THE DEVELOPMENT OF HIGHWAY TRANSPORT

I. EVOLUTION OF TRANSPORTATION.

A. Historical.
  1. Loads carried on the backs of men and women.
    a. Coolie labor.
    b. Negroes carrying raw material from the interior of Africa to the coast.
  2. Loads carried by animals.
    a. Caravans of early Egypt and the donkey of Palestine.
    b. Pack animals.
  3. Invention of the wheel.
    a. As early as 3,000 B. C.
    b. Two wheel carts and chariots of ancient Babylon.
  4. Use of waterways.
    a. Very primitive peoples made use of waterways.
    b. Inland waterways of the United States (4).
  5. Highways (1).
    a. Early Roman road system.
    b. Boston Post Road.
    c. York Road between New York and Philadelphia in 1711.
    d. Lancaster Pike in 1792.
    e. National Pike in 1811.
    f. Early toll roads and bridges.
  6. The railway (2).
    a. Baltimore and Ohio started in 1828.
    b. Greatest expansion since 1850.
      (1) 70,000 miles built between 1880 and 1890.
  7. The motor vehicle (3).
    a. First appearance in 1899.
    b. 411 motor trucks produced in 1904.
    c. About 11,000 motor trucks produced in 1911.
    d. 335,000 motor trucks manufactured in 1920.
    e. About 1,000,000 motor trucks now registered in the United States.
    f. About 9,000,000 passenger vehicles now registered in the United States.
    g. The motor truck and the World War. (5)
  8. The development of transportation on public highways.
    a. The horse and buggy.
    b. The stage coach or omnibus.
    c. The horse car.
    d. The cable car.
    e. The electric railway.
      (1) First four wheeled, then eight wheeled.

f. The four wheeled one man car or automobile.
g. The trackless trolley and motor omnibus.
h. The motor truck.

B. Relation of transportation to civilization.
1. Civilization has followed trade routes.
   a. Phoenicians spread eastern civilization.
   b. Romans extended their civilization throughout Europe.
   c. Columbus opened America for colonization.
2. Social intercourse a necessity for all men.
   a. Dependent in the towns and small villages upon transportation.
3. Education in rural communities dependent upon transportation.
   a. Group schools, farmers' clubs, college extension courses.
   b. 10 more children in 100 secure an education where roads are improved.
4. Distribution the greatest problem of our civilization.
   a. American industry specialized and grouped in districts.
   b. Food distribution dependent upon efficient transportation.

II. HIGHWAY TRANSPORT PROBLEMS.

A. Highways and vehicle one problem. (6)
1. Most efficient transportation the sole purpose of both.
   a. Roads must not be located by political pressure or local sentiment.
   b. Heavy grades add millions to haulage costs.
2. Effect of the road on the vehicle as well as the vehicle on the road must be considered.
   a. Too sharp curves cut down speed as well as throw heavy strain on tires.
   b. Rough surfaces cause high maintenance costs on vehicles as well as sharp impact on the road.
3. Problem concerns all, for all use the highway.

B. Future transportation must be co-ordinated.
1. Railway, electric railway, waterway, and highway transport each have their economical uses and limitations.
   a. Highway transport not a cure-all.
2. Lessons taught by the War. (7)
3. Over legislation concerning railways and its lesson.
4. Vision of future travel must determine what roads should be built.
5. High constructon expenditures even though ultimately justified must be deferred until a fairly complete system of moderately usable roads is obtained.

C. Most economical operation of motor vehicles must be established.
1. Importance of proper vehicle selection.
2. Efficient dispatching and routing necessary.
3. Complete cost records of vital importance.
4. Proper maintenance essential.
5. The drivers' co-operation must be obtained.
6. Lessons from European experience.
7. Lessons from other users.
8. Human life must be protected.

D. Some questions to be answered. (6) (8)
1. How much shall be spent to build a particular piece of highway?
2. What expense is warranted to maintain that piece of highway?
3. What type of surface should be laid for the different geographical sections?
4. The maximum traffic for which to be prepared.
5. How shall highway bonds be made gilt edge?
6. How shall we divide the responsibility of the government, the state, and the county for highway construction, control and maintenance?
7. What proportion of cost shall be borne by the vehicle?
8. How can the cost of vehicle operation be cut down?
9. What are sane regulatory laws?
10. How shall we tie highway, railway and water transportation together so that they will not compete but will serve each other?
11. What effect have grades on the cost of hauling?
12. What effect have different surfaces on the cost of hauling?
13. What effect have curves on the cost of hauling?
14. What effect have different vehicles on the cost of tires?
15. How should motor vehicles be taxed?
16. Under what conditions should a road be improved to take care of increased weight of traffic?
17. How shall traffic congestion in cities be met?

E. Magnitude of the problem.
1. Highway expenditures run into billions.
2. Automotive industry the second largest in the country.
3. 10,000,000 motor vehicles registered in the United States.
4. Efficient transportation necessary for the nation's existence.
5. Seventy-five millions Federal aid money appropriated for 1922.
6. In 1912 a Congressional Committee estimated a possible saving of $504,000,000 annually in transportation costs through improved roads.
   a. Motor vehicle registration in 1912 only one million.

7. Expenditures of the magnitude involved demand capable highway officials.
  a. Right brains can only be commanded by adequate salaries.

F. The highway program.
  1. Roads must be built as a country wide system.
    a. 225,000 miles would cover three-fourths of the total of the United States.
      (1) No person more than five miles from a main highway—average 2½ miles.
    b. 30,000 miles would be included in a National system.
    c. State and county systems selected by these respective political units.
  2. Highway improvements must be co-ordinated and continuous.
  3. Federal aid law of July 11, 1916.
    a. Amendment of November 9, 1921. (9)
  4. Effective maintenance essential.
  5. National defense highways.
    a. Pacific coast—1,500 miles.
    b. Canadian border—3,700 miles.
    c. Atlantic coast—2,000 miles.
    d. Mexican border—1,500 miles.
    e. Gulf coast—2,100 miles.

III. THE FIELD FOR TRAINED MEN.

A. Highway Engineers. (8)
  1. In public service.
    a. Qualifications.
      (1) Fundamentals of practical road building.
      (2) Fundamental knowledge of the motor vehicle.
      (3) Fundamental knowledge of methods of highway transport.
    b. Duties.
      (1) Location, construction and maintenance of highways.
    c. Field for employment.
      (1) Commissioner, director, or chief of federal, state, county, town or city highway department, bureau or board.
      (2) Chief engineer of such a highway body.
      (3) Assistant chief engineer or member of chief engineer's staff.
      (4) Division or district engineer.
      (5) Resident engineer.
      (6) Bridge engineer, or bridge engineer assistants.
      (7) Chemist, testing engineer, geologist.
      (8) Economist, research engineer.

    d. Personnel needed. (8)
      (1) Demand.
        (a) 9,600 men with engineering training employed by highway bodies in the United States outside of county and municipal organizations.
        (b) Ten per cent. replacements needed per year—960.
        (c) Per cent. employed according to rank.

1. Above division engineer	5
2. Division engineer	12
3. Resident engineer	26
4. Below resident engineer	51
5. Unclassified	6
Total	100

        (d) Increase of engineering control of roads expenditures.
          1. 1916—27 per cent.
          2. 1917—35 per cent.
          3. 1918—41 per cent.
          4. 1919—46 per cent.
          5. 1920—81 per cent.
      (2) Supply.
        (a) 1,000 to 1,100 graduates in civil engineering per year.
          1. Shared with railroads, construction companies, and industries.
    e. Salaries. (8)
      (1) Range upward to $12,000.
      (2) Salaries likely to be revised upward rather than downward.
    f. Other inducements.
      (1) More chance of permanency than industrial position.
  2. Highway contracting.
    a. Contractor.
      (1) Qualifications.
        (a) Same as highway engineer coupled with business training.
        (b) Few years with highway department good apprenticeship.
      (2) Duties.
        (a) Construction of highways and highway structures.
      (3) Personnel needed.
        (a) One billion dollars available for highways.
      (4) Compensation.
        (a) Profits limited only by ability.

- b. Highway engineer in employ of contractor.
    - (1) Qualifications same as for public service.
    - (2) Compensation limited by success of employer.
    - (3) Graduation into contracting ranks.
- 3. Salesmen for concerns manufacturing highway material and machinery.
  - a. Qualifications same as for highway engineer plus business training.
  - b. Compensation limited by size of concern—$4,000-$8,000 per year.
  - c. Graduation into business ranks.

B. Highway Transport Engineers. (8)
- 1. Qualifications.
  - a. Fundamentals of practical road building.
  - b. Possibilities and limitations of the motor vehicle.
  - c. How to anticipate trend and direction of urban and suburban traffic.
  - d. How to relieve congestion.
  - e. Forecasting the weight and volume of traffic.
  - f. Mechanical upkeep, operating economics, adaptability and types of motor vehicles.
- 2. Duties.
  - a. Transportation problems of communities and groups of shippers.
    - (1) Where should the roads be improved?
    - (2) Should one or half a dozen trucks be purchased?
    - (3) What type of equipment should be selected?
    - (4) Example—Michigan Fruit Growers' Exchange (8).
  - b. Transportation problems of the automotive industry.
    - (1) Accurate definition of customers' need.
  - c. Transportation problems of fleet operators.
    - (1) Selection of best routes.
    - (2) Selection of equipment.
    - (3) Economizing in operation.
  - d. Traffic regulation in cities.
- 3. Field for employment.
  - a. Federal, state and county offices.
  - b. Positions with large cities.
  - c. Industrial organizations operating big truck fleets.
  - d. Large motor service operators.
  - e Truck manufacturers and distributing organizations.
  - f. Ship-by-truck bureaus.
- 4. Personnel needed. (10)
  - a. Rapid growth of automotive industry has far outrun the trained men available.
  - b. Future limited only by construction of good roads and production of motor cars.
  - c. Automotive industry now second largest in United States and limit not yet in sight.

- d. Compare advancement with that of men who went into railroading in its infancy.
    - (1) Now presidents of railroad companies.
- e. Salaries available.
    - (1) Salary a secondary consideration in industry for men who perform their duties well.

C. Motor truck fleet managers or owners. (8)
- 1. Qualifications.
  - a. Many failures due to lack of training of those in charge.
- 2. Duties.
  - a. Transportation manager or general director.
  - b. Delivery superintendent—to oversee loading.
  - c. Maintenance superintendent—garage and repair work.
  - d. Operation superintendent—drivers and routing.
  - e. Cost accountant—to collect and compile costs.
- 3. Personnel needed.
  - a. Average fleet of five trucks involves an investment of $30,000.00.
  - b. 20,000 such fleets in the country.
    - (1) All need one or more men in charge.
  - c. Fleet of ten five-ton trucks involves an investment of $120,000.00.
  - d. 1,000 fleet managers per year needed of which at least 50 to 100 should be technically trained.
- 4. Salaries.
  - a. Up to $6,000.00 at present with highway transport having practically developed since the war. (10)
  - b. Future advancement certain to be large.

IV. THE FUTURE OF HIGHWAY TRANSPORT.

A. Increasing mileage of good roads will bring greater use of the motor vehicle.
- 1. More extensive use by farmers.
- 2. More rural motor express lines.
- 3. Rural post trucks used by Post Office Department.
- 4. Use by railroads to replace non-paying branch lines.

B. Short haul L. C. L. freight will probably be hauled by motor.
- 1. Growing realization of the economies that can be effected.

C. Development of separate high speed and heavy traffic roads between congested centers.
- 1. Revival of toll roads. (10)

D. Elimination of street congestion.
- 1. Private rights of way.
- 2. Improved terminal facilities.
- 3. Heavy and light traffic streets.

- E. More economical operation.
  - 1. Improved routing, dispatching, and shipping room methods.
  - 2. Growing appreciation of the importance of delivery costs.
  - 3. More use of loading and unloading devices.
  - 4. Development of special bodies and special equipment.
- F. Increased use of motor bus in passenger transportation.
- G. Increased understanding of the importance of motor transport.

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SUPPLEMENTAL

3. "Motor Truck Transportation," F. Van Z. Lane. Preface.
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6. "The Economics of Highway Transport," Roy D. Chapin, N. A. C. C.
7. "Similarity of Military and Commercial Motor Transportation," Colonel B. Taylor, N. A. C. C.
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9. "Public Roads," December, 1921.
10. "Colliers' Weekly." January 28, 1922.

INTERRELATIONSHIP OF HIGHWAY, RAILWAY AND WATERWAY TRANSPORTATION

I. ALL FORMS OF SERVICE.

- A. Transportation a service of a public nature.
  - 1. Unified system necessary. (34)
    - a. Error in past has been in concentration on one form for a time.
      - (1) One unit cannot profitably be favored above others.
      - (2) Danger of overestimating value of highway transportation. (33)
    - b. Compare with factory.
      - (1) Large machines for some processes.
      - (2) Small machines for other processes.
  - 2. Rehabilitation of tranportation the pressing problem of country.
    - a. Waterways fallen into comparative disuse.
    - b. Very few railroad stocks above par.
      - (1) Freight cars carry only half of their capacity.
    - c. Electric systems largely in hands of receivers.
    - d. Motor transportation retarded by lack of road development.
      - (1) Burden of taxation.
      - (2) Adverse legislation.
- B. Comparative Tonnage and Mileage. (1)
    - a. Railroads 2,504,000,000 tons in 1918— 259,000 miles
    - b. Highways 1,200,000,000 tons in 1918—2,753,333 miles
    - c. Great Lakes and Mississippi 90,000,000 tons in 1918—15,000 miles of waterways.
- C. Government Subsidization.
    - a. Railroads—Land grants to early railroads.
    - b. Waterways—Continual large governmental appropriations.
    - c. Highways—Entire cost of road should not be charged against transport.
- D. Comprehensive plan needs. (35)

II. THE ELECTRIC RAILWAY.

- A. Passenger service.
  - 1. Public Attitude.
    - a. Use of trolley increasing in spite of handicaps. (2)
      - (1) Should not be subjected to unregulated competition. (3)
    - b. Public anxious to use motor bus even at increased fare. (2)
      - (1) London Omnibus Company. (2) (4)

            (2) Fifth Avenue Coach Company. (2)
            (3) Newark, N. J., jitney bus. (2)
        c. Public generally antagonistic to street railway companies.
            (1) Motor bus as an aid to regaining good will.
                (a) A help in meeting peak loads.
    2. Electric railway must be a monopoly to survive.
        a. Competing systems should be subject to the same taxes and schedule requirements. (46)
        b. Regulations must be regulative, not punitive.
        c. Competitors' responsibility for accidents must be enforced.
    3. Relative costs. (2) (26)
        a. England.
        b. Fifth Avenue Coach Company. (2) (5)
        c. Chicago Motor Bus Company. (2)
        d. Fay Motor Bus Company. (2)
        e. Operating costs nearly all higher for busses than for trolleys. (43)
        f. Small capital charge the main economy for the bus.
        g. Comparative example. (2)
    4. Duplicate transportation facilities not desirable. (2)
        a. Independent bus lines may be used where trolley service is not available.
            (1) Strict regulation as to schedule, responsibility, etc.
        b. Bus lines operated by trolley companies in conjunction with trolley service. (2) (6)
            (1) Saves unprofitable extensions. (7)
            (2) Available for emergency service.
            (3) Assists in meeting peak loads.
            (4) Direct service avoiding transfer during rush hours.
        c. Municipal ownership. (2)

B. Freight Service.
    1. Present conditions. (2)
        a. Amount of freight transported small compared with other agencies.
        b. Cannot usually compete with railroads for long haul.
        c. Cannot usually compete with trucks for short L. C. L. haul. (41)
            (1) Trucks furnish door to door service.
            (2) Trucks eliminate terminal delays.
    2. Field of the trolley.
        a. For customers directly along its line.
        b. Use of trucks as feeders very limited.
            (1) Economy of operation offset by unloading costs.

III. THE RAILWAY.

A. Passenger service.
    1. Long haul.
        a. Bus service feasible only in absence of rail service.
            (1) Long distance motor coaching.
                1. England. (8)
                2. United States. (9) (39)
    2. Short haul.
        a. Commuter service will continue to be furnished by railroads.
            (1) Railway right of way avoids city congestion.
        b. Flanged wheel equipment. (10)
        c. Flanged wheels in addition to regular wheels.

B. Freight service.
    1. Long haul.
        a. Truck cannot compete in operating cost with railway.
            (1) Ratio of labor required to tonnage. (1)
        b. Trucks useful for very valuable cargoes, in case of emergency, or absence of rail service. (47)
        c. Speed vs. cost. (44)
    2. Short haul. (11) (30) (32) (48)
        a. Terminal charge a large part of railroad rates. (12) (13) (31) (49)
        b. Cartage charges must be included in cost to consumer.
        c. Motor truck shipment usually includes (a) and (b).
        d. Length of haul must be such as to render

$$\frac{\text{transportation cost} + \text{terminal charges} + \text{cartage}}{\text{number of miles}}$$

        less than motor truck transportation costs per mile
            (1) Necessity for return loads.
            (2) Motor truck costs should include road costs. (45)
            (3) Much data needed.
                (a) Effect of weather, grades, tractive resistance.
            (4) Profitable radius of truck operation dependent on this data. From 50-150 miles. (22)
        e. Short haul unprofitable to railway companies. (12) (1)
        f. Short haul L. C. L. freight ties up freight terminals. (28) (29)
            (1) Use of motor truck for short haul would increase car mileage. (12)
            (2) Short haul cars spend 9/10 of time loading.
            (3) Cincinnati plan. (14) (15) (23)
            (4) Unit containers. (16) (17)
        g. Cars not used to capacity in L. C. L. service. (1)
            (1) Compare cost of freight car and number of trucks sufficient to carry average L. C. L. shipment.

h. Comparative costs. (18) (19) (20) (25) (27)
(1) Trucking costs must include liability for loss.
(2) Trucking companies must have responsibility for expedition.
i. Short lines vs. motor trucks. (1) (38)
3. Correlation of facilities.
a. Trucks extend zone contributing to railroads. (1) (40) (42)
b. Highway routes operated by railroad companies.
c. Uniform bill of lading necessary for proper correlation.
d. Combination of delivery agencies.
(1) Store door delivery. (24)

IV. WATERWAYS.

A. Extent. (21)
1. Present.
a. Great Lakes.
b. Rivers.
c. Barge canals.
2. Increasing future on account of increase in stream regulation, irrigation and flood control projects.
B. Passenger traffic.
1. A minor factor on account of speed.
C. Freight traffic.
1. Bulk products not demanding speed, transported cheaply.
2. Low capital charges.
3. Need for more efficient organization and management.
D. Future outlook.
1. Deepening of Hudson River.
a. Great Lakes made seaports.
2. Mississippi River improvements.
3. Lake Erie and Ohio Canal, etc.

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TRAFFIC ENGINEERING AND CITY PLANNING

I. INTERRELATIONSHIP OF TRANSPORTATION AND CITY PLANNING. (1)

A. Transportation a vital factor in city growth. (5)
  1. Life of community tends to crystallize in centers. (3)
    a. Wholesale and retail district.
    b. Amusement and educational centers. (5)
    c. Park and playground areas. (5)
      (a) Park units should be connected.
    d. Warehouse and factory districts.
    e. Freight and passenger terminals.
    f. Residence communities.
    g. Effect of over segregation.
      (a) Theaters and needle trades of New York City.
  2. Zoning laws.
  3. Intercommunication between centers. (3) (5)
    a. Rectangular system.
    b. Diagonal system.
    c. Radials and circuits.
    d. Topography and contour plan.
  4. Ideal transportation system must provide. (1)
    a. Easiest means of reaching each center.
    b. Easiest means of passing through each center.
    c. Easiest means of avoiding a center entirely by a by-pass route.
B. Expediency often overweighs careful planning. (1)
  1. Pittsburgh "Hump Removal" of only 14 feet.
  2. San Francisco rebuilt without betterment of its street plan.
  3. New York with three pieces of subway on Broadway.
  4. Cleveland permitting disruption of "Mall Plan."
C. Economies in planning.
  1. Non conformable construction eliminated.
D. Problems of Transportation in cities must be considered together.
  1. Electric railways, waterways, and railroads.
  2. Trucking. (4)
    a. Classes:
      (1) Truck livery.
      (2) Pick-up and delivery.
      (3) Trucking express.
      (4) Freight transfer.
  3. Terminal warehouse, and dock congestion. (4)
    a. Losses through excessive haul.
    b. Store-door delivery.
      (1) Unit containers. (See Interrelationship.)
      (2) Demountable bodies. (See Dispatching and Routing.)

c. Improvements in design.
d. Improved warehouse location.
4. Rush hour traffic congestion and freight movement.
5. Merchant and package transport.
E. An engineering problem.
1. Engineers logical men to solve these questions.

II. HISTORICAL. (1) (5)

A. Omnibus.
B. Horse Car.
C. Cable Car.
D. Electric Railway.
E. Monorail.
F. Elevated Railway.
G. Pneumatic Tubes.
H. Electric Subway.
I. Motor Vehicle and Trackless Trolley.

III. STREET TRAFFIC PROBLEMS

A. Increasing traffic capacity.
1. Removal of street car lines.
a. Effect of car tracks on traffic capacity. (2)
2. Widening of streets.
3. Moving sidewalks into arcaded ways under buildings
4. Moving sidewalks
5. Elevating sidewalks.
6. Prohibition of parking.
a. Municipal garages.
b. Methods of enforcement.
7. Control of front door delivery in congested districts.
a. Special hours for delivery.
8. Two level and three level streets.
9. Parallel thoroughfares for heavy and light traffic.
a. Elimination of grade crossing of heavy and light traffic roads.
b. Shall the cost be borne out of public funds or by additional taxation of motor vehicles?
10. One way traffic.
11. Freight trucking vs. trap cars.
B. Legal and financial procedure. (5)
1. Distribution of cost burden of improvements.
a. City as a whole—to extent of its interest.
b. General area directly benefited.
c. Area immediately adjacent.
2. Excess condemnation
a. To facilitate rearrangement of adjacent property lines.
3. Metropolitan districts.
4. Bond issues for public improvements.
a. Pay as you go policy desirable.

5. Taxation.
6. Frontage consent amendment.
7. Consolidation of condemnation suits.
8. Regulation of tramp carriers or jitneys.

IV. STREET RAILWAY PROBLEMS. (1)

A. Fare zone and zone service.
1. Fare zones tend to cause concentration of population.
2. Zone service meets opposition from outlying residents.
B. Through routes.
1. Relieves terminal congestion.
2. Speeds up line operation.
C. Rush hour congestion.
D. Merchant transport.

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HIGHWAY TRANSPORT SURVEYS

I. TRAFFIC CENSUS.

A. Historical. (1)
B. Purpose. (2)
1. Economic evaluation of the highway.
a. Amount and character of traffic over entire system.
(1) Example Maryland-Connecticut.
b. Traffic over auxiliary roads.
c. Nature of product transported.
2. Daily and seasonal variation of the traffic.
3. Proper design of highway.
a. Number, type and direction of vehicles during given periods of day.
(1) Two, three, or four track highway.
b. Tonnage per vehicle.
(1) Type and thickness of pavement.
4. Allocation of construction and maintenance funds.
a. Maintenance cost per unit of traffic.
b. Wear on different highways of similar construction.
5. To assist in obtaining cost of operating traffic over highways.
a. Total number of each type of vehicle.
b. Total tonnage.
6. To furnish data for formulation of traffic regulations.
a. Relative frequency of heavy and light loads.
b. Passenger and freight vehicles.
c. Horse drawn and motor driven vehicles.
C. Method.
1. Location of traffic stations.
2. Frequency and duration of counts.
a. When system is improved.
(1) Census at regular intervals throughout year.
(2) Seasonal, weekly and hourly variations.
(3) Night traffic.
b. When system is not generally improved. (8)
(1) Two weeks summer and fall seven consecutive days.
(2) Consecutive days of week separated by 7 to 15 days.
(3) Four periods three days each.
(4) Use of traffic factor. (11)
3. Classification.
a. Type of vehicle.
(1) Tonnage—gross and net.
(2) Number and frequency of heavier units.
(3) Reduction factors. (11)

b. Destination.
(1) Farm to town.
(2) Inter-town.
(3) Through or tourist.
4. Tally sheet.
a. Simplicity.
b. Must state any unusual conditions.
c. Examples.
(1) Maryland. (2)
(2) California. (3)
(3) Michigan.
5. Field Weighings. (11)
a. Loadometer.
b. Actual weights to check estimated weights.
c. Speed and weight regulating stations.
(1) Automatic stations.
D. Use (Of most value when system is improved).
1. Traffic profile. (4)
a. Comparison of number of vehicles per unit with maintenance per unit.
b. Comparison of tonnage of different vehicles with maintenance.
c. Comparison of number of vehicles and condition of road.
d. Comparison of condition of road and tonnage.
e. Comparison of effect of traffic and type of surface.
f. Comparison of type of subgrade and effect of traffic.
g. Direction of traffic.
2. Traffic map. (9) (12)
a. Shows zone of operation of various sized units.
(1) Permits building road to suit transportation units.
3. Relation of volume of travel to condition of constructed road.
a. 70% of total traffic uses state highway system—9% of total roads. (5)
b. 10% of highways carry 75% of load.
4. Determination of width and capacity of roadway. (7)
a. Traffic discharge of highway.
(1) Vehicles per hour.
(2) Ton-miles per year.
5. Peak loads on the highway.
a. Graphical presentation.
(1) Rectangular co-ordinates. (6)
(2) Polar co-ordinates. (7)
b. Scheduling of traffic to secure more even distribution.
(1) Increased capacity of highway.
(2) Increased speed of operation.

II. ECONOMIC SURVEY (of particular value with unimproved roads).

- A. Analysis of transportation needs of industries—urban and rural. (10)
  - 1. Commodity to be hauled.
    - a. Indicates suitable vehicle types.
      - (1) Maximum vehicular weight.
        - (a) Strength of surfaces.
      - (2) Speed.
      - (3) Length of haul.
  - 2. Volume of traffic.
    - a. Effects width of road, and attrition of surface.
    - b. Possible fatigue of road if maximum load is applied frequently.
- B. Central sources of traffic. (10)
  - 1. Character of towns and cities.
    - a. Distance between them.
  - 2. Population.
  - 3. Climate.
  - 4. Distribution of wealth.
  - 5. Buying habits.
  - 6. Other forms of transportation—steam, electric, water
    - a. Relation of location of roads.
    - b. Economic haul.
  - 7. Condition of existing roads.
    - a. Effect of improvement of roads in increasing number of vehicles.

III. VEHICLE REGISTRATION.

- A. Vehicles registered in vicinity will immediately use roads.
  - 1. Weight and type.
  - 2. Kind of tires.
- B. Increase in registration in similar district with road improvement.
  - 1. Graphical presentation of statistics.

IV. INTANGIBLES.

- A. The passenger vehicle.
- B. Social value.
- C. Educational value.

PROBLEMS

1. Plot using polar co-ordinates assigned traffic census data showing distribution of traffic by hours of day, or day, or week.
2. Plot the traffic profile of a given road.

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ECONOMICS OF LOCATION

I. GENERAL CONSIDERATIONS. (1)

- A. Principle. The road must be located so that the maximum of transportation can be furnished at the least cost.
  - 1. Cost of road and cost of vehicle operation not paid by one company as in case of railroads.
  - 2. Transportation furnished must be cheapest possible to the consumer instead of furnishing greatest profit to the railway company.
    - a. Increased distance does not increase the revenue as in the case of the railway company.
    - b. Any feature of location effecting the final volume of traffic must be considered.
  - 3. Length of road.
    - a. Deviation may cause greater volume of traffic.
      - (1) Road should pass close to sources of traffic (towns, etc.).
        - (a) Possibility of high speed through roads avoiding towns, and parallel low speed heavy traffic roads passing through towns.
    - b. Cost of road construction per ton-mile of traffic least with maximum of traffic.
    - c. Deviation of main road usually more costly to transportation, all factors considered, than use of short branch roads.
      - (1) Relative volume of through and way traffic.
  - 4. Road must be so located as to stimulate traffic.
    - a. Only a small part of traffic is strictly necessary for existence.
    - b. Burden of the cost of the road to the community goes on whether road is used to maximum or not.
  - 5. An error in location is as a rule not capable of remedy.
  - 6. The cost of the road is small in relation to the cost of operation of traffic.
    - a. It requires a marked engineering disadvantage in location to overbalance a saving in the cost of operation of vehicles or an increase in the volume of traffic.

II. MINOR DETAILS OF ALIGNMENT.

- A. Importance. (2)
  - 1. A short straight line with few curves or grades not necessarily best.
  - 2. Items in cost of operation effected are the smallest ones.
    - a. Additional cost of running few more miles small.
    - b. Effect of curvature on operating expense small.

    - c. Effect of rise and fall on cost of operation small.
    - d. Depreciation, driver, license, insurance, taxes, garage, interest, supervision, lost time (60% of cost of operation) not effected.
    - e. Gasoline, lubricants, tires, repairs, etc. (40% of cost of operation), effected only slightly.
    - f. Maintenance of road, first cost, interest, sinking fund, etc., effected only slightly.
  - 3. Only a small difference in minor details of alignment possible for a given road.
  - 4. Sacrifice of good ruling gradients and reaching more sources of traffic not warranted to get "short straight and level line."
    - a. Section line roads quite often not engineering locations.
- B. Distance—Principle—Any deviation that will increase the average number of tons per mile of road is desirable as a matter of public policy. (3)
  - 1 Small changes in distance—up to 2 miles.
    - a. Effect of distance more important in highway transport, than in connection with railway operation, for it effects the cost of operation without any compensating return in increased revenue.
    - b. Effect on operating expenses (hypothetical example).
      - (1) The cost of operating an additional mile not the same as the average cost.
        - (a) The annual cost of the road varies directly as the distance. This is not more than 8% of the cost of operation of traffic per ton mile.
          - 1. Dependent on volume of traffic.
        - (b) Possible 60% of the gasoline and oil cost varies directly as the distance.
          - 1. Loss in starting, stopping, braking, idling, warming up, etc.
        - (c) Not more than 60% of tire cost varies directly as the distance.
        - (d) Not more than 50% of cost of repairs varies directly as the distance.
          - 1. Time and age of unit.
          - 2. Starting and stopping.
          - 3. Curvature and grades.
          - 4. Over-loading and over-speeding.
          - 5. Effect of distance.
        - (e) Summary based on 1,000 tons per day, 300 days per year. Road costing $35,000 per mile. Annual cost $6,000. Passenger vehicles not considered.

Item	*Cost of operation	% of cost of operation	% effected by distance	% of total effected by distance
Road	2.00¢	7.0	100.0	7.0
Gasoline	3.70	14.4	60.0	8.6
Oil	0.40			
Tires	4.30	15.1	60.0	9.1
Repairs	2.00	7.	50.0	3.5
Depreciation	3.50	56.5	00.0	0.0
Chauffeur	4.30			
License, Insurance, Tax, etc.	0.90			
Garage	1.30			
Interest	0.55			
Supervision	2.24			
Lost time	3.26			
Total	28.45	100.0		28.2% of cost of operation varies with distance

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*Cost figures are average figures for a 2-ton truck.

2. Medium changes in distance—two miles to fifteen miles.

a. Effect on operating expenses (using same hypothetical data as above).

1.	Annual cost of road same		7.0%
2.	Gasoline and oil	possibly 90%x14.4%	13.0%
3.	Tires	possibly 85%x15.1%	12.8%
4.	Repairs	possibly 75%x 7.0%	5.2%
5.	Drivers' wages	possibly 50%x15.1%	7.5%
	Total		45.5%

of cost of operation varies with distance.

3. Justifiable expenditure to reduce distance.

a. Small changes.

(1) 28.2%x28.45 per ton mile = 8 cents per ton mile = additional cost of operation caused by increase of one mile in distance.

$8¢ \times \frac{300}{5280} \times$ number of tons passing over road per day = cost of one additional foot of distance in operation of trucks per year.

$8¢ \times \frac{300}{5280} \times 1000 = \$4.55$ = cost of one additional foot of distance in operation of trucks under these conditions.

(2) $28.2\% \times 7¢$ per vehicle mile $= 2¢ \times \frac{300}{5280} \times$ number of passenger vehicles per day = cost of one additional foot to passenger vehicles per year. (For the sake of illustration, assuming the same percentage of operating expense effected as for a truck.)

(3) (1) + (2) ÷ prevailing rate of interest = justifiable expenditure to remove one foot of distance.

b. Medium changes.

(1) $45.5\% \times 28.45¢$ per ton mile $= 13¢ \times 300 \times$ number of tons per day = cost of one additional mile in operation of trucks $= 13 \times 300 \times 1000 = \$39{,}000$.

(2) $38\% \times 7¢$ per vehicle mile $= 2.7¢ \times 300 \times$ number of vehicles per day = cost of one additional mile of distance to passenger vehicles. (Not considering any drivers' wages and for the sake of illustration, assuming the same percentage of operating expense effected as for a truck.)

(3) (1) + (2) ÷ prevailing rate of interest = justifiable expenditure to remove one mile of distance.

4. Large changes in distance.

a. Effects number of trips per day and therefore the number of vehicles necessary for a given tonnage.

b. Increases practically all items of expense.

c. Possibly 70% of cost of operation varies directly with the distance.

C. Curvature.

1. Danger of accident exaggerated. (9) (4)

a. Question for engineer is never curvature or no curvature, but how much?

2. Effect on speed of operation. (4) (12)

a. Curves up to 500 feet radius properly banked do not materially effect speed. (10)

(1) Superelevation. (10)

b. Mathematical analysis. (10)

(1) Centrifugal force varies as the square of speed and directly as the curvature.

3. Effect on operating expenses.

a. The wear on tires the principal item.

4. Maintenance of road.

a. Increased maintenance on curves.

5. Justifiable cost to reduce curvature within above limits very small.

D. Rise and fall. (5)

1. Classification.

a. Grades not requiring use of brakes or increase in power.

(1) Grades less than 2% do not invite coasting

b. Grades demanding slight use of brakes and shutting off power but not necessitating gear shift.

c. Grades demanding gear shift and full power in ascending and brakes in descending.

2. Grade resistance. (Values.) (14) (19)

- 3. Grades cannot be considered individually but in series.
  - a. Virtual profile. (6)
- 4. Method of reduction. (14) (19)
  - a. Increased distance will not decrease operating expenses.
    - (1) Miles per gallon of gasoline not proportional to reduction in grade.
  - b. Cutting and filling.
    - (1) Reduces length or rate of descending grade decreasing coasting.
- 5. Cost of rise and fall.
    - (1) Grades where application of brakes is necessary increase operating expense and should be avoided as much as possible. (6)
  - b. Data necessary.
    - (1) Determination of items of operating expense and per cent. each bears to total expense.
    - (2) Determination of effect on each item of one foot rise and fall.
    - (3) Determination of total traffic.
    - (4) Methods of calculation.
      - (a) Class b (see distance).
      - (b) Class c (see distance).
- 6. Safe limits.

B. Ruling gradient and curvature.

- 1. Effect on load.
  - a. No grade steeper than can be negotiated by a horse-drawn vehicle should be used.
  - b. Present trucks can lift capacity loads up ordinary grades now used.
  - c. Number of trailers limited by ruling grade. (17)
    - (1) A truck can pull three or four times what it can carry. (11)
    - (2) Method of calculation. (18)
  - d. Inability to use pusher grades as on railroad makes it desirable to reduce all grades as near to the average as possible.
  - e. Much experimental data necessary to determine effect on load.
- 2. Effect on operating cost.
  - a. Data necessary.
    - (1) Determination of items of operating expense and per cent. each bears to the total operating expense.
    - (2) Determination of effect of each per cent. in increase of grade.
    - (3) Determination of total traffic.
    - (4) Sample calculation. (See distance.)
- 3. Effect on time of operation.
- 4. Compensating for curvature on ruling gradient.
  - a. Use of sags in grade line. (7)
- 5. Limiting effect of curvature (8)
  - 6. Detours to avoid grades.

PROBLEMS

1. A road between points A and B, one hundred miles apart, is deflected 10 miles to strike a third point C. The road is to be concrete at $40,000 per mile. A through traffic of 300 vehicles per day is expected, 200 being passenger vehicles and 100 trucks averaging 2 tons capacity. By deflecting the road it is expected that 100 additional vehicles will use the road, 25 being 2-ton trucks and 75 being passenger vehicles. Which will be the more economical:

(1) To construct the road straight between A and B, thereby eliminating C,
(2) To deviate the main road so that it will pass through C,
(3) To construct a feeder road from C to the road AB?

2. Assuming gasoline consumption to vary as shown in the accompanying table calculate the gasoline consumption for each of four possible roads from A to B one mile apart and with grades as shown. Assume no gasoline consumption on descending grades.*

Grade	Miles per Gallon†
Level	16.0
1	12.7
2	10.6
4	7.9
6	6.3
8	5.3
10	4.5
12	3.9
15	3.3

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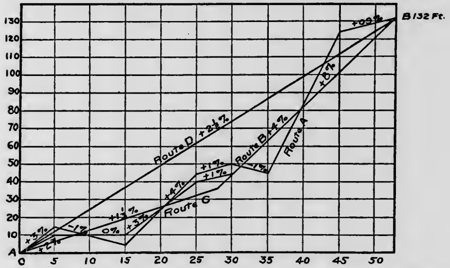
†Robert C. Barnett, Economic Engineer for Missouri State Highways Transport Committee, for a 2-ton load.

*H. S. Fairbanks, Senior Highway Engineer, Bureau of Public Roads.



3. Construct a virtual profile for each of the grades in problem 2.

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ECONOMICS OF SELECTION OF TYPE OF SURFACE

I. GENERAL CONSIDERATIONS.

- A. Principle—Highways and motor vehicles must be adapted one to the other so that the greatest economy of transportation will result. (19) (22)
    - 1. Certain types of hauling can be done most economically with heavier units of traffic. (2)
    - 2. Road construction and maintenance expense for different sized traffic units will determine ultimate economy of large or small units.
    - 3. Experimental data on haulage costs and road expense necessary.
    - 4. On railroads locomotive designers have considered both economy of increasing train loads, and economy of track and road bed construction.
- B. Motor truck the limiting factor. (23)
    - 1. Roads suitable for trucks will carry passenger vehicles and horse drawn traffic satisfactorily.
    - 2. Maximum weight, speed, tire, equipment, unsprung weight, distribution of load, etc., determine types of road necessary.
    - 3. Volume of traffic unimportant in determining type.

II. LIMITS. (14)

- A. Weight. (1) (13) (15) (17) (20)
    - 1. Impracticable to look more than 5-10 years ahead.
        - a. At 5% interest, present worth of $1.00 due in ten years is $0.61.
        - b. Uncertainty of future traffic is very great.
        - c. Present construction should provide for future improvement.
    - 2. Motor vehicle manufacturers have agreed upon a 28,000-pound limit.
        - a. Proposed uniform vehicle law.
    - 3. Present laws impose limits ranging from 20,000 pounds to 30,000 pounds.
    - 4. User must make constant use of entire truck capacity to realize maximum economy.
    - 5. Use of trailer makes possible increased capacity without development of larger trucks. (11)
    - 6. Solid tires limit weight to approximately 30,000 pounds.
        - a. Pneumatic tires not yet used extensively on larger sizes. (3) (24)
    - 7. Additional tons capacity yield diminishing returns in operating expense as capacity is increased. (2)
    - 8. Goodyear six-wheel truck. (12)

9. 800 pounds per inch width of tire a common limit.
    - a. New French road law restricts load per inch width of tire, but says nothing about total weights.

B. Speed.
1. N. A. C. C. standard—25 miles per hour.
2. Existing laws—10-35 miles per hour.

III. ECONOMICAL TRAFFIC UNIT.

A. Data necessary.
1. Types of road necessary to withstand various traffic units.
    - a. First cost.
    - b. Maintenance costs.
    - c. Cost of policing if types less than that for maximum unit is selected.
    - d. Economical life of road when (total cost of repairs + costs of renewal of surface) ÷ years of life = minimum. (6)
2. Number and type of traffic unit likely to use road. (Obtainable from traffic studies or economic survey.)
3. Relative operating costs of various sized units.

B. Typical investigation (assumed data).
1. 1 — 1½ — 3 concrete road. (4)

Trucks Thickness required:	1½ Ton 5″	2 Ton 5.5″	3 Ton 6.4″	4 Ton 7.1″	5 Ton 7.7″	7½ Ton 8.9″
a. Cost	$30,000	$33,000	$38,400	$42,600	$46,200	$53,400
b. Maintenance	1,000	1,000	1,000	1,000	1,000	1,000
c. Policing	200	200	200	200	200	....
d. Economical life.	10 yr.	10 yr.	10 yr.	10 yr.	10 yr.	10 yr.

2. Traffic count (vehicles per day). (5)

Passenger Autos			Trucks				Horse Drawn	
Light	Heavy	Busses	Less than 1 T.	1-2½ T.	3-5 T.	5 T.	Vehicles	Total
			EAST					
278	357	29	51	35	24	60	32	1,661
			WEST					
238	320	29	64	32	22	53	37	1,640
516	677	58	115	67	46	113	69	3,301

3. Relative operating costs.

Capacity	2	3	4	5	6	7½
Total cost of operation per loaded ton mile in cents	26.45	24.63	22.13	21.65	20.15	19.00

4. Calculations.

Total tonnage 115 × 1 ton = 115
67 × 2 tons = 134
46 × 4 tons = 184
113 × 5.6 tons = 633

Total 1066 tons per day × 300 = 319,800 tons per year.

Transportation cost per mile per year by various sized units:

2-ton trucks = 26.45 × 319.800 = $84,600
3-ton trucks = 24.63 × 319.800 = 78,700
4-ton trucks = 22.13 × 319.800 = 70,700
5-ton trucks = 21.65 × 319.800 = 69,300
7½-ton trucks = 19.00 × 319.800 = 60,700

Where F = cost of construction
r = prevailing interest rate
M = annual maintenance charges
S = sinking fund requirements based on economical life, cost to reconstruct and prevailing interest rate
P = cost of policing to enforce traffic regulations

Annual cost per mile of roads = Fr. + M. + S.* + P+rΣM
2-ton roads = 5.5″ A.C. = 33000 × .05 + 1000 + 2625 + 200 = 5475
3-ton roads = 6.4″ A.C. = 38400 × .05 + 1000 + 3050 + 200 = 6170
4-ton roads = 7.1″ A.C. = 42600 × .05 + 1000 + 3380 + 200 = 6710
5-ton roads = 7.7″ A.C. = 46200 × .05 + 1000 + 3770 + 200 = 7280
7½-ton roads = 8.9″ A.C. = 53400 × .05 + 1000 + 4250 + 0 = 7920

The last item may be neglected, being the same for all roads in this example.

TOTAL COST OF TRANSPORTATION (Assuming same number of smaller units as at present)

	Operating Cost	Road Cost	Total Transportation Cost
2-ton or less—			
115 tons × 29¢ = $ 33.35			
951 tons × 26.45 = 251.54			
$284.89 × 300 days =	$85,467	+ $5,475	= $90,942
3-5 Tons—			
115 tons × 29¢ = $ 33.35			
134 tons × 26.45 = 35.44			
817 tons × 22.13 = 180.80			
$249.59 × 300 days =	$74,877	+ $6,710	= $81,587
5 Tons—			
115 tons × 29¢ = $ 33.35			
134 tons × 26.45 = 35.44			
184 tons × 22.13 = 40.72			
633 tons × 21.65 = 137.04			
$246.55 × 300 days =	$73,965	+ $7,280	= $81,245

7½ Tons or Less—
115 tons × 29¢ = $ 33.35
134 tons × 26.45 = 35.44
184 tons × 22.13 = 40.72
348 tons × 21.65 = 75.24
285 tons × 19.00 = 54.15

$238.80 × 300 days = $71,640 + $7,920 = $79,560

Therefore assuming the above costs it would be true economy to build a 7½-ton road.

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*Assumes extreme case of very short life and road requiring to be entirely rebuilt.

IV. OTHER FACTORS EFFECTING TYPE OF CONSTRUCTION.

A. Provision for maintenance.
  1. Skilled or unskilled.
B. Local Materials.
C. Character of foundations. (16) (27)
D. Aesthetic considerations.
E. Tractive resistance. (1) (18) (21) (25)
  1. Effect on fuel consumption. (26)
  2. Effect on time per trip.
F. Effect on vehicle maintenance.
G. The whole financial traffic, and highway situation in the unit of government to be served. (7)
  1. Greatest good to the greatest number.
  2. Both lowest and highest grade roads may be truly economical. (8)

PROBLEM

1. Classify all trucks over two tons as heavy trucks and consider the proportions of heavy trucks which would use a given mile stretch of road to be 48.6%—3 ton, 27.3%—4 ton, 19.3%—5 ton, 3.5%—6 ton, and 1.3%—7 ton. (Registration in Maryland in 1918.) Assume the present road to be 8-inch macadam 16 feet wide, costing $1.10 per square yard. Assume that heavy trucks would require 14-inch macadam 20 feet wide. Find the number of heavy trucks using the road which would justify the improvement, assuming maintenance costs to be the same. Use the transportation costs given in the above outline. Assume the life of the road to be 10 years when it can be renewed by replacing the upper three inches of macadam at one-third the cost of a new road.

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EFFECT OF THE VEHICLE ON THE ROAD

I. TYPE OF VEHICLE.

- A. Horse Drawn.
  - 1. Abrasion.
    - a. Can be taken care of by proper maintenance.
- B. Light, fast, rubber-tired traffic. (12)
  - 1. Present designs satisfactory.
- C. Heavy motor truck. (1) (15) (16)
  - 1. Stresses induced.
    - a. Shear.
      - (1) Surface cracking and rutting.
    - b. Bending.
      - (1) Wavy pavements.
    - c. Abrasion.
      - (1) Rupture on top surface.
    - d. Vibrating action.
      - (1) Rupture of slab throughout.
  - 2. Type of failure.
    - a. Road slab.
      - (1) Structural failure.
    - b. Subgrade.
      - (1) Support not constant.
  - 3. Effect of weight.
    - a. Impact.
      - (1) Unevenness of road. (9)
      - (2) Effect of unsprung weight. (9)
      - (3) Spring pressure. (9)
      - (4) Type and condition of tires. (9) (17)
        - 1. Solid.
        - 2. Cushion.
        - 3. Pneumatic.
      - (5) Experimental determination.
        - (1) Description of apparatus.
          - 1. Copper cylinder. (5)
          - 2. Space time curves. (3)
        - (2) Description of tests.
          - 1. Using trucks. (2)
          - 2. Using impact machine. (4)
        - (3) Results of tests. (2) (4)
          - 1. Tests too few to be conclusive.
      - (6) Effect of speed on impact. (2)
        - (1) Possible for light high speed trucks to produce high impact compared to heavy trucks at low speed.
    - b. Static load.
      - (1) Effect of sprung weight in increasing static load.
  - 4. Effect of speed.
    - a. Surface wear proportional to tractive effort which is slightly greater at high than low speeds.

II. TYPE OF ROAD.

- A. Rigid type. (6)
  - 1. Conditions to be met.
    - a. Slab supported on soft subgrade.
    - b. Slab spanning circular soft spot in subgrade.
    - c. Slab supported at sides of road, two trucks passing.
    - d. Slab supported along center line, two trucks passing.
      - (1) Longitudinal construction joint.
    - e. Single wheel—load applied at corner of slab.
  - 2. Reinforcing steel does not add appreciably to resisting moment.
- B. Non rigid type. (6)
  - 1. Conditions to be met.
    - a. Maximum pressure transmitted not to exceed bearing valve of subgrade in its worst condition. (13) (14)
      - (1) Use of soil pressure cell in determination of pressure. (8)
      - (2) Improvement of subgrade conditions. (7)
      - (3) Determination of bearing valve of soils. (11)
- C. Comparison of various types of surface.
  - 1. Lack of experimental data.
  - 2. Effect of impact on both types. (4)
  - 3. Accelerated wear tests. (10)

III. TRAFFIC INTENSITY. (6)

- A. Width of road.
  - 1. Structural failure induced when traffic is forced off shoulders.
  - 2. Trucks require wider road than passenger vehicles.
    - (1) Trucks up to 93" wide run 9-10 miles per hour.
    - (2) Eighteen to twenty-foot road required for two-way traffic.
- B. Effects rate of disintegration of wearing surface.

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SELECTING THE VEHICLE

I. GENERAL REQUIREMENTS.

A. The field for selection.
    1. Several hundred makes and models. (1) (2)
B. Capacity. (3)
    1. Average load to be carried.
        (a) Maximum and minimum.
    2. Character of load.
C. Power. (3)
    1. Nature of topography.
        a. Gear ratio.
    2. Character of roads.
        a. Tractive resistance.
D. Speed. (3)
    1. Closely related to size and weight.
    2. Commodity to be hauled.
E. Size and character of body. (3) (6)
    1. Distinguish between size and carrying capacity.
F. Operating conditions. (3)
    1. Legal restrictions.
        a. Effecting use of trailers, width, loads, etc.
    2 Clearance.
    3. Height of body.
    4. Length of wheel base.
G. Service. (5)
    1. Standard parts.

II. TYPE OF TRUCK.

A. Gasoline driven.
    1. Rear wheel driven.
        a. Chain.
        b. Worm.
        c. Gear.
    2. Four wheel drive.
    3. Tractor trucks.
    4. Six wheel trucks.
        a. In experimental stage.
B. Electric driven.
    1. Street trucks.
        a. Advantages.
    2. Industrial.
C. Vocational survey.
        a. Use under similar conditions (see typical uses).

III. BODY DESIGN.

- A. General construction. (6)
  - 1. Size and weight limitations.
- B. Stationary bodies. (6)
  - 1. Stake and rack bodies.
  - 2. Keg rail.
  - 3. Express.
  - 4. Grocers' bodies.
  - 5. Van.
  - 6. Lumber.
- C. Dumping bodies. (6) (4)
  - 1. Garbage.
  - 2. Asphalt.
  - 3. Gravity dump bodies.
  - 4. Mechanical dump bodies.
    - a. Hoists.
    - b. Elevating and dumping.
- D. Demountable bodies. (6) (4)
  - 1. Telepherage. (7)
  - 2. Roll off.
- E. Special bodies (6) (4) (11)
  - 1. Refrigerator.
  - 2. Char-a-blanc.
  - 3. Tank bodies.

IV. TRAILERS.

- A. Theory. (5)
  - 1. Railroad analogy.
  - 2. Draw bar pull. (8) (5)
- B. Advantages. (10)
  - 1. Increase in load hauling capacity.
  - 2. Reduced cost of transportation.
  - 3. Saves loading and unloading time.
  - 4. Moves special loads.
  - 5. Takes care of peak haulage.
    - a. Reduces maintenance due to elimination of overloading.
  - 6. Use with passenger cars.
- C. When to use the trailer. (5)
  - 1. Ton mile costs sometimes increased, sometimes decreased.
  - 2. Tractive resistance of roads.
  - 3. Maximum grades.
  - 4. Charting the day's run.
  - 5. Speed of operation.
    - a. Effect of shifting gears.
  - 6. Comparative costs. (10) (5)
    - a. Itemized comparison with and without trailers.
  - 7. Special conditions. (5)

- D. Construction. (10)
  - 1. Must be suitable for high speed.
    - a. Bearings, lubrication, etc.
  - 2. Brake equipment.
  - 3. Tire equipment.
  - 4. Effect on truck construction.
  - 5 Steering gear.
- E. Typical uses. (10)
  - 1. Semi-trailers.
  - 2. Four-wheel trailers.

V. TIRES.

- A. Construction. (9)
  - 1. Solid.
  - 2. Pneumatic.
  - 3. Cushion.
- B. Comparison. (12) (13) (14) (19)
  - 1. Advantages claimed for pneumatic tires. (15) (16) (17) (20) (21) (22)
    - a. Reduction in mechanical repairs.
    - b. Increase in permissible speed.
    - c. Decrease in gas consumption.
    - d. Less vibration and therefore less fatigue for driver.
    - e. Less depreciation of roads. (23)
    - f. Greater tractive ability.
    - g. Some truck manufacturers disagree with. (a) (b) (c) (d) and (e)
  - 2. Disadvantages. (18) (20)
    - a. High initial cost.
    - b. Need of carrying emergency equipment.
    - c. Difficulty of changing on roads.
    - d. Reduction of high gear ability due to increased diameter of wheels.
    - e. Limitation imposed on size of brakes.

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DISPATCHING AND ROUTING

I. FUNDAMENTALS.

A. Definitions. (1)
  1. Routing so plans distribution that the necessary service required may be accomplished according to schedule by the available equipment.
  2. Dispatching directs the movement of equipment over routes according to schedule.

B. Principles.
  1. Every ton-mile or passenger-mile of transportation available and not used represents an economic loss. (1)
    a. Keep the wheels turning.
    b. Deliver the maximum quantity of freight with the least wheel turn.
    c. Never let freight grow old.
      (1) Shipping room can stop a factory.
    d. Make the maximum of tonnage deliveries with the minimum of vehicles.
    e. Load and unload as few times as possible.

II. SCHEDULING. (2)

A. Co-ordination of loads and vehicles.
  1. Load must be ready when truck is ready.
    a. Zone system.
    b. Definite truck schedule.
  2. The right load ready for the right truck.
    a. The dispatcher.
    b. Location of all trucks constantly recorded.
      (1) Typical methods.
  3. Assembling the load.
    a. Typical systems.
  4. Eliminating garage delays.
    a. Typical example.

III. ROUTING. (3)

A. Zone system basis of successful routing.
  1. Planning the zone.
    a. Large scale map essential.
    b. Density of trades.
    c. Number of stops.
    d. Number of deliveries necessary.
    e. Radius of vehicle operation.
      (1) Number of trips per day.
  2. Analyzing routes by time studies.
    a. Time loading.
    b. Time unloading.

      - c. Time full speed.
      - d. Time half speed.
      - e. Typical example.
  - B. Other factors effecting successful routing.
    - 1. Ferry delays.
      - a Avoiding peak loads.
    - 2. Congested bridges and streets.
      - a. Selection of routes to be avoided.
      - b. Avoiding peak loads.
    - 3. Condition of roads.
      - a. Up to date record desirable.
      - b. Driver should be informed.
    - 4. Depot system of delivery.
    - 5. Terminal delays.

IV. MECHANICAL AIDS.

- A. Loading devices. (4)
  - 1. Demountable bodies.
  - 2. Use of trailers.
  - 3. Nest bodies.
  - 4. Individual hampers.
  - 5. Escalators.
  - 6. Belt conveyors.
  - 7. Spiral gravity chutes.
  - 8. Gravity roller conveyors.
  - 9. Power winch.
- B. Unloading devices. (5)
  - 1. Dump bodies.
  - 2. Gravity chutes.
  - 3. Hack bodies.

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ENGLISH HIGHWAY TRANSPORT METHODS

Outline Submitted by A. H. Blanchard, January 31, 1922

I. DEVELOPMENT FROM 1850 TO 1922

- A. Effect of completed systems of highways.
- B. Effect of legislative acts.

II. TYPES OF COMMERCIAL VEHICLES.

- A. Tractors and traction engines and trailers.
- B. Steam lorries with and without trailers.
- C. Petrol motor trucks with and without trailers.
- D. Motorbusses.
- E. Char-a-bancs.

III. LEGISLATION IN FORCE IN 1922.

- A. "British 1861 Act for Regulating the Use of Locomotives on Turnpikes and Other Roads."
- B. "British 1878 Highways and Locomotives Act."
- C. "British 1898 Locomotives on Highways Act."
- C. "British 1904 Heavy Motor Car Order."

IV. HIGHWAY TRANSPORT METHODS.

- A. Freight haulage.
  - 1. Municipal methods.
  - 2. Rural methods.
  - 3. Railways as operators of freight highway transport.
- B. Passenger transportation.
  - 1. Municipal motor bus routes.
  - 2. Intercity motor bus routes.
  - 3. Railways as operators of motor bus routes.
  - 4. Rural transportation by char-a-bancs.

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Files of the weekly English periodicals, Commercial Motor, Modern Transport and Motor Transport.

ECONOMIC SURVEYS

I. PURPOSE.

- A Bringing to light all items entering into transportation cost.
  - 1. Methods of boxing and crating. (1)
  - 2. Sorting and assembling.
  - 3. Routing and internal delivery.
- B. Transportation or delivery costs relatively unknown. (2)
  - 1. Labor, production, sales and accounting costs considered essential.
  - 2. Haulage rates must be based on entire cost of service.
- C. Most efficient methods of transportation should be used.
  - 1. Present system of food distribution probably most expensive in history.
  - 2. Many failures in motor transportation due to attempting the uneconomic.
  - 3. Increased service to public.

II. SURVEYS OF BUSINESS OPERATIONS.

- A. Effect of location. (3)
  - 1. Access to railroad siding or navigable river.
  - 2. Convenience to yards and shipping points.
  - 3. Street layout, grades, condition of pavement and congestion.
- B. Effect of plant layout. (3)
  - 1. Loading and dispatching facilities.
  - 2. Location of elevators and conveyors.
  - 3. Relation of inside and outside transportation.
  - 4. Size and height of shipping platforms.
  - 5. Location of garage or stable.
  - 6. Loading and unloading devices—(See Dispatching and Routing).
- C. Character of service necessary.
  - 1. Long and short haul. (5)
  - 2. Frequent stops. (4)
    - a. Long or short duration.
  - 3. Co-ordination of horse, electric and gasoline trucks (4) (5)
    - a. Field and advantage of each.
  - 4. Character of merchandise.
  - 5. Special bodies—(See Selecting the Vehicle).
  - 6. Proper size of system.
- D. Traffic management.
  - 1. Effective routing and scheduling—(See Routing and Dispatching).
  - a. Return trips.
  - 2. Garage management.
  - 3. Cost system—(See Cost Keeping).
  - 4. Standardization.

- E. Examples.
  - 1. Milk industry (4).
  - 2. Ice dealer. (5)
  - 3. Ice cream dealer. (6)
  - 4. Lumber industry. (7)
  - 5. General manufacturing. (3)

III. PUBLIC HAULAGE SURVEYS.

- A. Year-round road condition, character of bridges. (2)
  - 1. Effects kind of equipment.
  - 2. Effects cost of operation.
  - 3. Snow removal
  - 4. Possible detours.
  - 5. Attitude of public officials toward regular use of roads.
  - 6. Traffic laws, ordinances and regulations.
  - 7. Running time possible.
    - a. Probable number of stops.
    - b. Maintaining a schedule.
- C. Amount and kind of freight available. (8)
  - 1. Attitude of merchants, shippers, etc.
    - a. Toward existing service.
    - b. Toward proposed service.
  - 2. Population of region it is proposed to serve.
  - 3. Return loads bureau. (10) (11)
    - a. Operated like employment agency.
    - b. Motor truck terminal companies.
  - 4. Motor truck terminals.
- B. Existing transportation service. (8)
  - 1. Rail and electric.
    - a. Frequency of service.
    - b. Existing rate.
    - c. Time of delivery of existing service.
    - d. Possible connections.
      - (1) Rail, waterway, street cars, other truck routes.
- D. Scale of charges. (8)
  - 1. Based on complete estimated costs.
    - a. Data regarding existing routes.
      - (1) Fixed charges, operating costs, maintenance charges.
      - (2) Soliciting business, advertising, etc.
    - b. Length of haul, condition of roads, etc.
  - 2. Minimum charge and maximum size and weight.
    - (1) Loading facilities.
  - 3. Charge on fragile and perishable goods should cover responsibility for loss.
  - 4. Charge for passengers based on competing service.
  - 5. Rates for both bulk and weight.

- E. Miscellaneous. (8)
  - 1. Securing of capital
  - 2. Reliable drivers available.
  - 3. Provision for occasional accident.
    - a. Perishable goods.

IV. COMMUNITY TRANSPORTATION SURVEYS. (9)

- A. Population.
  - 1. Past growth and estimated future growth.
  - 2. Nationality, education, progressiveness.
  - 3. Buying habits.
  - 4. Distribution of wealth.
- B. Industries.
  - 1. Character and volume.
  - 2. Location of markets.
- C. Existing transportation.
  - 1. Present rail, electric, and water facilities.
  - 2. Possible extensions.
  - 3. Existing roads.
    - a. Present condition.
    - b. Contemplated improvements.
  - 4. Travel habits.
    - a. Present freight and passenger movement.
  - 5. Present truck transportation.
    - a. Degree of organization.
- D. Recommendation.
  - 1. Detailed analysis of traffic movement with proposed rearrangement.
  - 2. Estimated costs of proposed additions.
  - 3. Effect on existing transportation of proposed changes.
  - 4. Analysis of present revenue from transportation.
  - 5. Analysis of estimated revenue from proposed system.
- E. EXAMPLE. (9)

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INDUSTRIAL USES OF MOTOR VEHICLES

I. FARMS.

- A. Market gardening (vegetables, etc.). (1) (4)
- B. Livestock. (2) (4)
- C. Cotton. (3) (13)
- D. Fruits. (4)
- E. Grain. (13)
- F. Dairying. (4)
- G. Use of tractor. (13)
- H. General. (5) (6) (7) (8)

II. LUMBER. (9) (13)

- A. Logging.
- B. Milling.

III. OIL. (10) (13)

IV. MINES. (11) (13)

V. FACTORY. (12)

- A. Apparel. (13)
- B. Baking. (13)
- C. Barrel and Box. (13)
- D. Bottling. (13)
- E. Central station. (13)
- F. Chemicals. (13)
- H. Furniture. (13)
- I. Gas. (13)
- J. Hardware. (13)
- K. Ice. (13)
- L. Iron and Steel. (13)
- M. Laundry. (13)
- N. Meat. (13)
- O. Milling. (13)
- P. Textile. (13)

VI. CONSTRUCTION. (14)

- A. Building. (13)
- B. Building materials. (13)
- C. Road building. (13)

VII. LOCAL.

- A. Grocery stores. (13)
- B. Department stores. (13)

VIII. MUNICIPAL. (13)

- A. Fire protection.
- B. Police patrols.
- C. Garbage removal.
- D. Paving.
- E. Street cleaning.

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TRANSPORTATION USES OF MOTOR VEHICLES

I. AUXILIARY.

- A. As a feeder to railways. (1)
    - 1. Flanged wheel equipment. (2) (3) (4)
    - 2. Flanged and road wheel equipment.
    - 3. Express companies. (6)
- B. As a feeder to waterways.
- C. Co-ordination of all facilities. (5)

II. INDEPENDENT.

- A. Inter-city.
    - 1. Passenger.
        - a. Description of operation. (7)
        - b. Success. (7)
    - 2. Freight.
- B. Rural motor express. (8) (6)
    - 1. Co-operative associations. (9)
    - 2. Private. (8)
    - 3. Governmental (parcel post). (8) (10)
    - 4. Success. (11) (12) (13)
- C. Motor busses.
    - 1. Consolidated schools. (14) (15) (16) (17)
    - 2. Trackless trolley. (18) (19) (20) (25)
    - 3. Bus lines. (21) (22) (23)
- D. Local.
    - 1. Taxicabs. (6)
    - 2. Local transfer work. (6)
- E. Long and short rural haulage.

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